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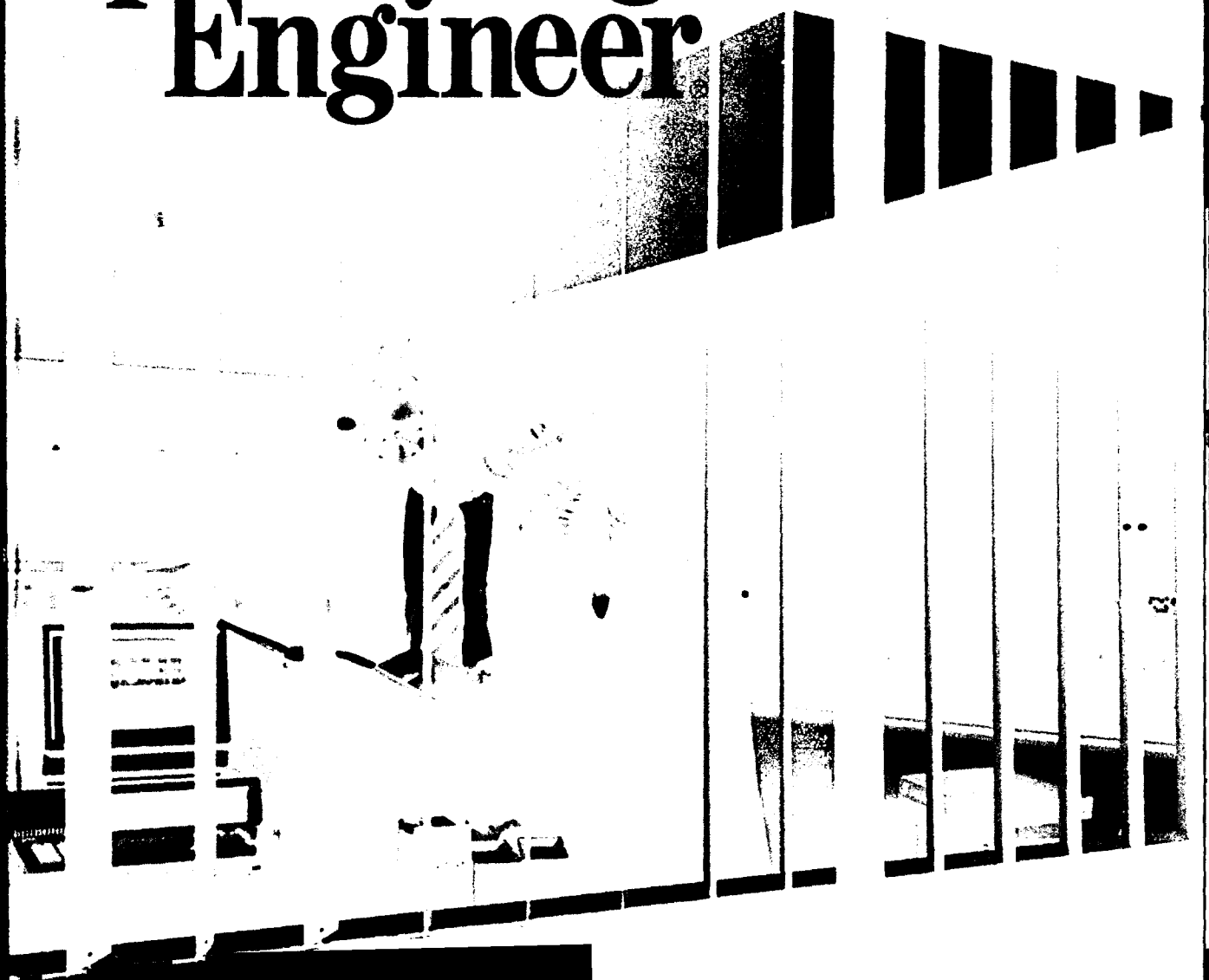

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The New Horizon
Indoor Environmental Quality

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◀ *Designing an indoor environment that is both comfortable and functional can be done with efficiency and style from the perspective of the new horizon: indoor environmental quality.*

▼ *Not just an assembly of design parameters, the new horizon of indoor environmental quality means designers must grasp the total effect of these factors on the occupant.*

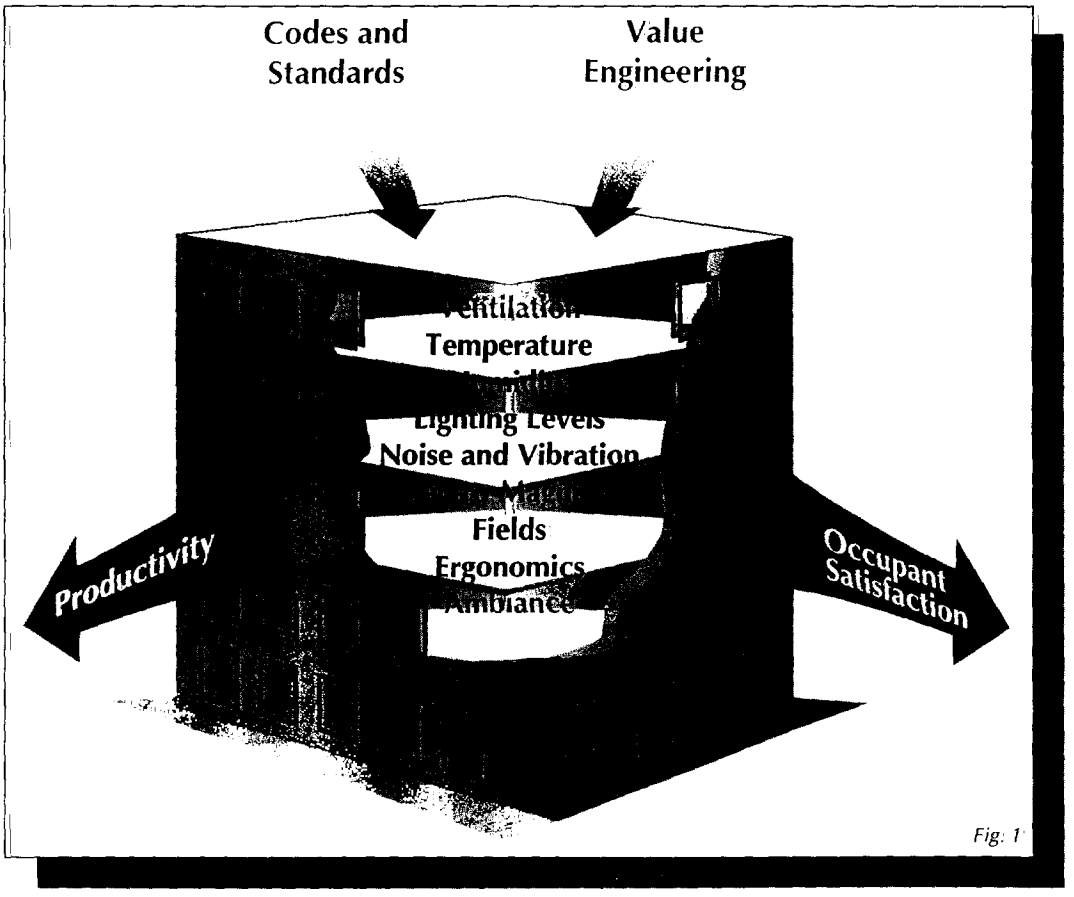

Fig. 1

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The New Horizon

Change is in the wind. Change in the manner in which people use buildings. Change in the expectations people have of their workplace environment. Change in the way buildings must be designed and maintained to meet new demands. For engineers charged with designing new and retrofit office construction projects, the force of change creates a new horizon: total indoor environmental quality.

Like other major trends in office construction, the shift of focus to the broad perspective of indoor environmental quality will produce a complete rethinking of how buildings are planned, designed, built, started-up, and operated. And, like other major trends, indoor environmental quality will not replace past practices, but will extend and overlay the positive aspects of past building practices. Indoor environmental quality will not discard the efficiency improvements gained in the move for energy conservation of the past twenty years, as many predict. Instead, it will absorb the lessons learned by engineers through their energy experience and integrate efficiency into the most basic systems and equipment from earliest planning to operations.

Offices of today and the future will need to meet increasingly stringent demands for proper design and management to achieve good indoor environmental quality, which includes such issues as ergonomics, light, noise, decoration, ambiance, and organizational and personal dynamics, as well as ventilation and indoor air quality. Total indoor environmental quality means addressing the needs of the occupants, and balancing and accommodating those needs where necessary to achieve cost effective construction and operation of buildings.

Technical creativity and design finesse provide solutions for this challenge. For example, a range of positive choices is available to balance the requirements of smokers and nonsmokers in the use of indoor space. The development of methods for accommodation of smokers represents an excellent case study for developing a model of good management practice for the indoor environment.

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Understanding the Indoor Environment

Aesthetics and functionality once provided sufficient measure of the quality of the design of indoor office workspace. Engineers concerned themselves with temperature and humidity for thermal comfort, and sufficient ventilation to overcome the odors produced by human occupants. Architects and interior designers selected floorplans, furnishings and amenities to meet the budget and taste of their clients, creating an "ambiance" that suited the building and its occupants. Such criteria for quality offer part, but not all of the design parameters that will combine in determining indoor environmental quality in the future.

The emerging science of indoor environmental quality combines subjective factors, such as aesthetics, with quantifiable factors, ranging from the quality of the indoor air, to ergonomic conditions, noise and light levels. Occupant perceptions of health, safety, comfort, and productivity, once separate concerns in building design, now combine in the larger context of indoor environmental quality. Grappling with the concept of indoor environmental quality, designers must look broadly at physical and operational design parameters, integrating factors as wide-ranging as traditional issues of interior design and ambiance, setting new standards for maintainability, and even reaching subjects such as organizational and personal dynamics *(See Fig. 3)*. These factors interrelate to form a whole that yields both the perception and the reality of good indoor environmental quality.

Accommodating Smokers Under ASHRAE 62-1989

A key step in using the accommodation model for designing a high quality indoor environment is analyzing codes and standards that apply to the specific use being accommodated. While local codes may have specific requirements that apply to accommodation of smokers, ASHRAE Standard 62-1989 represents the current national standard of broadest applicability. For the present discussion, the ASHRAE Standard will be used as an example of the role of codes and standards in the process of assessing technology for the accommodation model of indoor environmental quality. Central references to designing for accommodation of smokers and non-smokers in ASHRAE 62-1989 include the following:

- **Foreword:** Provides history of the development of the ventilation standards, noting the importance of accommodating smoking, among other uses, and the changes in technology that have motivated changes in the Standard over time.
- **Section 4, Classification,** defines "Ventilation Rate Procedure" and "Indoor Air Quality Procedure" as design methodologies for determining specific requirements in varying HVAC applications.
- **Section 5, Systems and Equipment,** includes discussion of particulate filters and vapor and gas removal devices for supplemental air cleaning.
- **Section 6.1, Ventilation Rate Procedure,** prescribes the methodology for use of the ventilation rate values provided in Table 2.
- **Table 2, Outdoor Air Requirements for Ventilation,** the heart of the Standard, prescribes design outdoor air quantities and maximum occupancy levels for a wide variety of specific uses of indoor environments, including smoking lounges, and explains that the requirements were set "to account for health variations among people, varied activity levels, and a moderate amount of smoking."
- **Section 6.1.3.1, Multiple Spaces,** provides for the use of "transfer air," air which moves from one indoor space to another, to supply smoking lounges and other areas with exhaust systems.
- **Section 6.1.3.2, Recirculation Criteria,** defines the conditions under which recirculated air can be substituted for outdoor air.
- **Section 6.1.3.3, Ventilation Effectiveness,** defines a methodology for calculating ventilation effectiveness and allows for use of plug flow, or displacement, ventilation.
- **Section 6.1.3.4, Intermittent or Variable Occupancy,** defines parameters for calculating ventilation rates when the number of occupants in an area varies over time, as it does in a smoking lounge.
- **Section 6.2, Indoor Air Quality Procedure,** establishes an alternative methodology that allows ventilation rates to be adjusted to achieve effective removal of known contaminants, and to meet subjective evaluation criteria, including a specific discussion of environmental tobacco smoke.

Fig. 2

An Engineering Perspective

Elements of the building that are controllable from an engineering design and operational perspective revolve around balancing the projected uses of each space with its operating parameters. Indoor environmental quality factors, even those so remote from traditional engineering as organizational dynamics and stress, can be influenced by the plan for how each space within a building will be used, and the resulting decisions about the physical characteristics specified for it. Good design practice for achieving good indoor environmental quality begins with a space use plan far more detailed and sophisticated than those seen in past practice.

The plan for use of the space within a building designed and operated for good indoor environmental quality requires multi-dimensional conceptualization of how occupants will perceive their environment and act within it. Floorplans will be supplanted with useplans which incorporate layers of detail:

- **Basic floorplan** lays out primary use, basic building systems and amenities
- **Extended floorplan** details special uses that require upgrades to building systems
- **Occupant floorplan** lays out choices about use patterns, such as office equipment and smoking preferences, as well as anticipated times of occupancy and special uses of space
- **Air quality plan** details emission rates from various fixed sources, such as carpeting, furniture, and construction materials, as well as variable sources, such as levels of

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occupancy, smoking, and kitchen use, and how source management and ventilation will control occupant exposures

- **Maintenance plan** details how equipment will be maintained, and how sources of contamination from maintenance, such as cleaning fluids and pesticides, will be managed to minimize occupant exposure
- **Ergonomic plan** details workflow planning and how the layout of the space will accommodate ergonomic considerations to minimize physical stress points in the workplace, ranging from properly designed and adjusted chairs and desks to glare-free computer stations and acceptable levels of noise and vibration

A Model for Indoor Environmental Design

These plans incorporate traditional application of design parameters and standards at each step, providing a baseline of traditional quality assurance. But by assembling these plans into a multi-dimensional whole, the planned interior space can be evaluated for environmental stress points—locations and times in which the layout or operation of the space and its supporting systems might fail to avoid, or might actually add to, the physical or psychological stress placed on building occupants. Reducing environmental stress points to a minimum, while conscientiously attempting to create an ambiance that meets the taste and budget of the occupants, provides the highest probability that a design will result in good indoor environmental quality over the many years that the building is occupied.

Developing a useplan which provides good indoor environmental quality presents a series of decisions that balance the needs of occupants and make tradeoffs to bring the plan within budget limitations. One example of occupant use, accommodation of smokers and non-smokers, offers an example of how the useplan can be valuable in design decisions basic to achieving good indoor environmental quality in new or retrofit applications. Examination of the various approaches and technologies available to engineers to design for accommodation of smokers provides a model for how to develop a useplan to set the new standards of good design and management practice for indoor environmental quality.

Table One
Indoor Environmental Quality Factors

Factor	Elements	Design Tools	Subjective & Objective Criteria	Standards and Guidelines
Comfort	Temperature Humidity	HVAC specification Zoning for use Air distribution	Individual comfort Static electricity Microbial growth	ASHRAE 55-1981, Thermal comfort; 111-1988, Test and balance; Guideline 1-1989, Commissioning of HVAC systems
Air Quality	Ventilation Chemical emissions Bioaerosols Particulates and dust	HVAC specification Filtration system Material selection Local exhaust Zoning for use Air distribution	Odors Irritation and health complaints Visible dust Scientific sampling and analysis	ASHRAE 62-1989, Ventilation; 90.1-1989 and 100.2–100.6, Energy; 52-1968 (RA76) and 52.1-1992, Filtration testing ACGIH Guidelines for the Assessment of Bioaerosols in the Indoor Environment; Industrial Ventilation: A Manual of Recommended Practice NADCA duct cleaning standards
Utility	Light levels Noise levels EMF	Lighting specifications Material selection Daylighting Work flow analysis HVAC equipment selection	Light intensity and color Glare EMF measurements Noise dba and vibration levels Aural distraction	IES Lighting Handbook ASHRAE 90.1-1989, incl. lighting; 68-1086, Fan noise testing methodology AIHA Noise and Hearing Conservation Handbook
Ergonomics	Floorplan Furniture Office equipment	Useplanning Adjustable work stations	Physical stress Relative physical position for specific tasks Individual comfort	NSC Ergonomics: A Practical Guide AIHA Ergonomics Guides OSHA proposed rulemaking
Ambiance and Human Interactives	Accessibility Decorations Floor coverings Wall coverings Fixtures Furniture Lighting Noise levels	Accommodation Lighting Color Perspective Material selection	Psychological stress Use limits Emissions Comfort Taste	BOMA ADA Compliance

ACGIH (American Conference of Governmental Industrial Hygienists) — ADA (American Disabilities Act) — AIHA (American Industrial Hygiene Association) — ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) — BOMA (Building Owners and Managers Association International) — IES (Illuminating Engineering Society) — NADCA (National Air Duct Cleaners Association) — NSC (National Safety Council) — OSHA (Occupational Safety and Health Administration)

Fig. 3

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Strategies for Accommodating Smokers

High-Rise Buildings

High-rise buildings present some of the most dramatic architectural statements of the twentieth century — and some of the most difficult and complex indoor environments to manage. Some of the largest high-rise complexes provide an office workplace for more than ten thousand occupants daily, while others provide a combination of office, retail and even residential uses in a single structure, reaching skyward as high as one hundred stories. With the structural challenges of high-rise construction now mastered, raising the level of indoor environmental quality provides a new horizon.

Designing an approach to accommodating smokers in a high-rise building demonstrates some of the key challenges in achieving good indoor environmental quality in the epitome of modern architecture. First, the populations of such buildings are large, and comprised of a majority of working adults. National statistics show that about twenty-six percent of the adult population of the U.S. currently smoke. In a high-rise building with ten thousand working occupants, as many as twenty-six hundred may be smokers.

Most high-rise buildings have accommodated smokers by allowing smoking throughout the building or by restricting smoking in public areas, but allowing it in tenant spaces. Recently some building managers have experimented with requiring smokers to exit the building to smoke. The impracticalities of this approach become overwhelming for some simple reasons: using our sample high-rise, and assuming smokers would exit the building an additional two to four times a day to smoke, between five thousand and ten thousand additional elevator trips would be added to the daily vertical transportation load. That adds stress to the building system and energy load. The solution also adds substantial stress to twenty-six hundred building occupants, who expose themselves to the vagaries of the outdoor environment. Alternative approaches can reduce both energy penalties and the environmental stress created by the radical solution of banning smoking indoors.

Options for an Accommodation Strategy

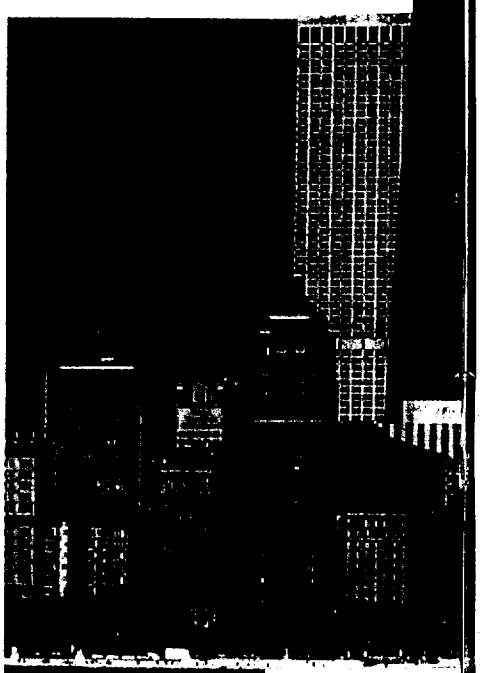
Accommodating smokers and nonsmokers in a high-rise building can be done in several ways. Three general options that can work are

- Provide sufficient ventilation based on ASHRAE guidance *(See Fig. 2)*
- Designate smoking areas, where additional ventilation, negative pressure zones, or improved filtration compensate for a concentration of smoke in a small area
- Establish smoking lounges, where separate ventilation and exhaust systems remove smoke from general ventilation

Challenges in Existing Buildings

The existing stock of high-rise buildings represents a variety of design parameters for ventilation as the standards have varied over the past decades. Some of these buildings were designed using lower ventilation rates than those suggested in ASHRAE Standard 62-1989, presenting a complex challenge for retrofit increases in ventilation. Where following the ASHRAE recommended rates may be impractical, building managers seeking to enhance indoor environmental quality may need to look at alternative approaches for improvements in air quality, including revising use patterns to fit ventilation needs, and adding filtration to improve the quality of recirculated air.

Revising use patterns is an interactive process among building management, designers, and occupants. Looking at the example of how to accommodate smokers and nonsmokers, options include restricting smoking in general use spaces where ventilation is insufficient and providing defined smoking areas or lounges. For smoking areas, added filtration may present the simplest option for keeping smoke from being introduced into general use ventilation air. Use of prefilters,



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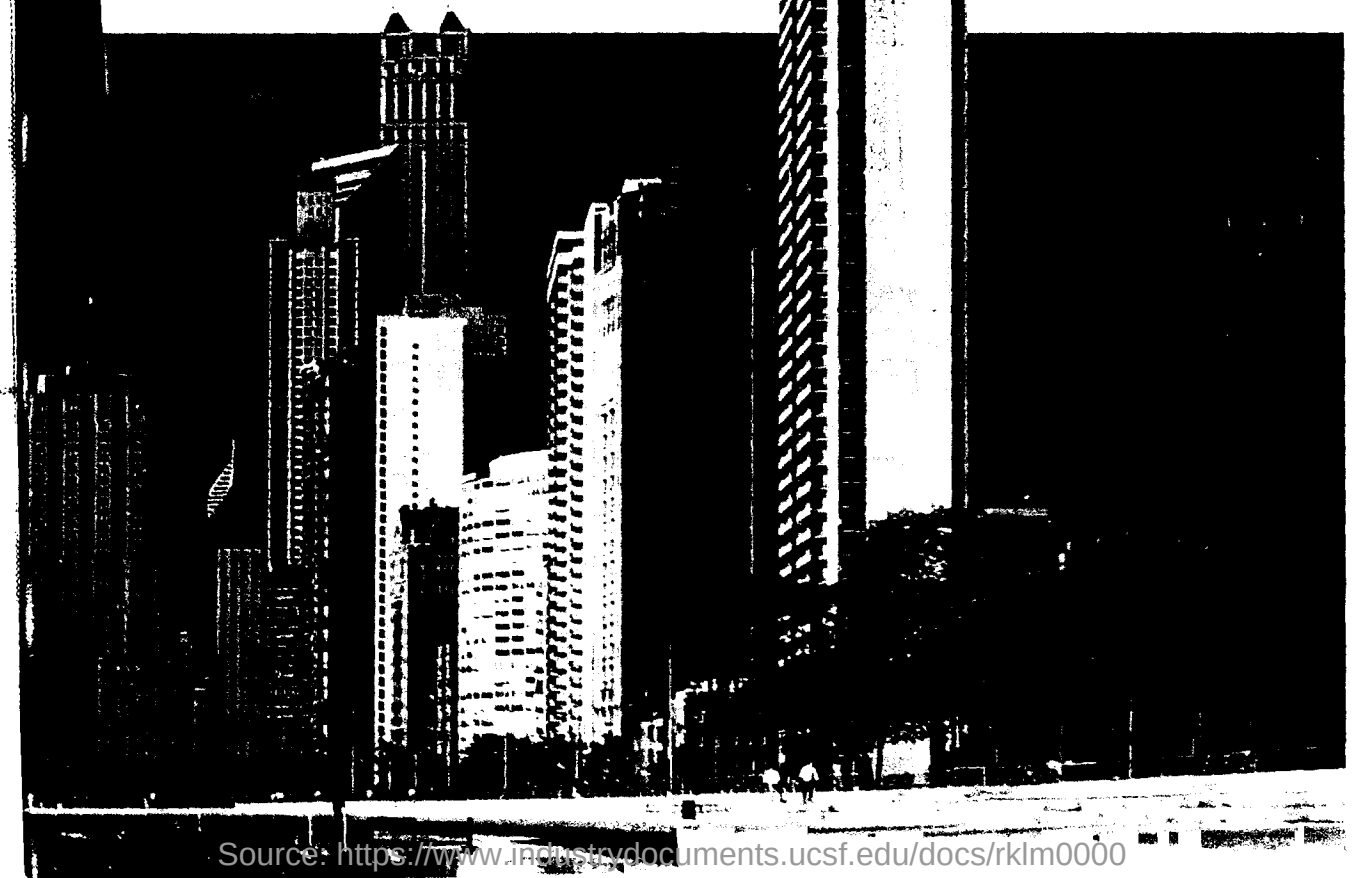
carbon filters, and final high efficiency particulate filters has proven effective for this purpose. By using zoning of the air handling system to minimize the portion of total return air needing this advanced filtration, energy and cost penalties for this improvement to the indoor environment can be kept to a minimum.

Establishment of smoking lounges presents more specific challenges in the context of a high-rise building retrofit. High-rise buildings typically provide only minimal exhaust from occupied floors to avoid adding to the "chimney effect" that complicates all high-rise ventilation design. The existing exhaust system must be evaluated for its capacity to handle an additional sixty cubic feet per minute of exhaust per smoking lounge occupant, and for the supply system to provide a compensating amount of make-up air. If capacity is sufficient, location of smoking lounges in the vicinity of an existing exhaust point will minimize the installation costs.

Opportunities in Major Renovations and New Designs

Where major renovation work or new design allows, high-rise buildings offer an excellent opportunity for the installation of new technologies that provide convenient accommodation for smokers and non-smokers. The high degree of environmental control implicit in high-rise design makes installation of special features potentially cost effective options, such as wall-less smoking areas that isolate smoke using air pressure, or use of displacement ventilation, floor plenum air supply, or personal environmental control modules. While these improvements require an initial capital investment, the net gain in the quality of the indoor environment, and the net efficiency improvements in building performance may outweigh the costs.

Developing a cost effective approach to good indoor environmental quality in a high-rise building requires a high degree of cooperation among owner, manager, and occupants, and collaboration with the designer, as can be seen in the example of accommodating smokers. The determination of occupancy levels for smoking areas or lounges presents a key aspect in calculating ventilation and filtration requirements for the designer. Yet, the occupant loading factors can only be determined in cooperation with the tenants, whose smoking policy may influence requirements. A policy based on smoking lounges and pre-established group smoking break times may seem simple to the occupants, but it results in the maximum number of occupants in smoking lounges during very concentrated periods of time. On the other hand a staggered schedule of smoking breaks, or an open policy, reduces the probable number of occupants of the smoking lounge to a more manageable number. When large populations, such as those found in a high-rise, are the basis for design, open policies for smoking lounge use represent the most cost effective and convenient method of planning for both occupants and designers.



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Strategies for Accommodating Smokers

Mid-Rise Buildings

Mid-rise office buildings represent a substantial and growing portion of the office workspaces of today and the future. These buildings frequently offer the amenities of a high rise facility, with restaurants, shops, and other benefits that higher density use can afford. At the same time, they represent very diverse designs and engineering challenges. For example, HVAC systems for mid-rise buildings range from relatively simple ceiling plenum, passive return and exhaust systems to sophisticated powered variable volume supply and exhaust designs. The diversity makes each building an individual challenge in developing an approach to achieving good indoor environmental quality.

The diversity of uses and the relatively compact design of mid-rise buildings offer some advantages in the development of programs to accommodate both smokers and non-smokers in the indoor environment. The tenant-oriented design of many mid-rise buildings, which often results in HVAC system zoning based on tenant layout, provides an opportunity for each tenant to determine their own smoking policy. In addition, since many mid-rise structures incorporate cafeterias and other services with special ventilation needs, such as dry cleaners, HVAC systems frequently include the flexibility to add exhaust ventilation to specific areas. This flexibility makes it easier to develop designated smoking areas and lounges for the general use of the building occupants.

The supply of office space in mid-rise buildings grew dramatically throughout the 1980s, resulting in a highly competitive market for such space during this decade. Competition for leasing mid-rise space has grown so intense in most major US metropolitan areas that building owners and managers must use quality features, as well as price, to retain tenants and win new ones. A substantial part of the everyday effort to provide a quality facility focuses on traditional "sprucing-up" of the building appearance, with new carpeting, paint, wallpaper, and signage. But the tenant's agent of the 1990s and the future will look for a broader range of fundamental quality indicators. For some large corporations, it is already routine to do a preliminary environmental assessment of potential leased space. Sufficient accommodation for smokers and non-smokers will likely become part of the new tenant's list of features as they seek better indoor environmental quality.

A Tenant-based Approach for Accommodation

Flexibility in meeting the needs of individual tenant organizations is a primary requirement for leasing in most mid-rise buildings. Tenants range from small businesses to large, from suites of less than one thousand square feet to multiple floors. From computer rooms to break rooms, many of the spaces specified in a tenant's plan for office space may require special consideration to achieve indoor environmental quality.

Amid such diversity, accommodating a tenant's smoking policy becomes an important opportunity. For many tenants, allowing smoking anywhere in their space may be desirable, or they may elect to set aside specific smoking and non-smoking areas within their space. Tenants in smaller spaces, where setting up separate smoking areas may not be feasible, often prefer the building to provide a central smoking lounge to accommodate employees and guests who smoke. Buildings which incorporate restaurants or cafeterias also need to evaluate how to accommodate the needs of smokers and non-smokers in these public places.

Engineering Solutions

For new designs, with ventilation rates based on ASHRAE Standard 62-1989, ventilation should be sufficient to allow smoking in tenants' space. However, for older buildings designed with lower ventilation rates than suggested in the 1989 Standard, design options include increased ventilation with outdoor air or improved filtration, combined with improved useplanning. By developing a detailed useplan with the tenant, the wide range of indoor environmental issues can be integrated into an effective zoning and ventilation plan that supports specific uses, including smoking areas. The zoning plan may specify added outdoor air or filtration, and possibly localized exhaust, to achieve the best possible balance for the indoor environment within the tenant's budget.

Buildings which elect to develop a central smoking area or lounge stand to gain a distinct competitive advantage, provided the facility is well designed and operated. For new construction, design options abound, including such cutting edge approaches as displacement ventilation and wall-less pressure zones for smoking lounges. For retrofit

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▲ *Mid-rise office buildings can improve their competitive position by accommodating tenant smoking policies and other diverse uses tenants require from their facilities today.*

applications, where an existing restaurant or cafeteria already requires specific exhaust systems, locating a central smoking lounge or area in the vicinity of the eating area will reduce the complexity and cost of including the smoking lounge. Within eating areas, designated smoking areas can be managed by use of careful zoning and pressure relationships.

By designing in central accommodation of smokers, building owners and managers in mid-rise buildings can offer tenants the widest range of accommodation solutions for their convenience. And the accommodation approaches available provide the maximum benefit to indoor environmental quality.

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Strategies for Accommodating Smokers

Small Office Buildings

The fastest growing portion of the commercial office space market in many parts of the U.S. today is the single story office park. Ranging from single buildings to dozens of acres of facilities, and often mixing office and light industrial or warehouse functions, these widely dispersed workplaces now play an important role in housing the American worker. With relatively simple structural and mechanical designs, their popularity has grown for many reasons: great flexibility for multi-purpose use, convenient locations for highway transportation, and relatively low capital and leasing costs. Small and mid-size businesses, employers of the majority of the US workforce, use the "build-to-suit" option for this type of space to accommodate their specific needs.

The challenges for managing indoor environmental quality in these facilities often derive from the same design features that make them so popular. Factors such as comfort, air quality, ergonomics, and ambiance often take a distant backseat to utility, structural capacity, security, and low initial construction cost. Several typical design features generally contribute to the environmental challenges: small rooftop ventilation systems, small bathrooms and kitchens scattered throughout the space, minimal separation of industrial or warehouse support systems from office areas, floors and walls with high thermal gradients. The single most significant advantage for managing these indoor environments comes from the flexibility inherent in the ventilation system, and the ease with which changes in ventilation can be made.

The accommodation of smokers and non-smokers in single story office facilities has generally been approached as a policy issue, either allowing or banning smoking. Where smoking is restricted in occupant office space, smokers generally resort to the industrial or warehouse space, common areas of the building (where they exist), or the outdoors. But the design features of single story office spaces make them excellent candidates for establishing smoking areas and lounges, or even accommodating individual smokers. And, as part of designing or retrofitting properly zoned and balanced HVAC systems, the additional capital and operating costs prove minimal.

Small System Environmental Design Characteristics

The quality of the indoor environment in single story office buildings often rests primarily on the design and operational parameters of the ventilation system. While the many other factors that contribute to good indoor environmental quality are no less important in this setting, the spartan nature of the buildings and the limits of their simple design and construction techniques reduce the concept of quality to its most fundamental elements. Ventilation is the primary element of concern because it is also the most frequent source of quality complaints in this type of building. For all of the simplicity and flexibility of this style of design, single story office buildings often lack sufficient supply of outdoor air, and sometimes transport contaminants from one part of the building to another through poorly zoned HVAC systems. Perhaps because of the simplicity of these buildings, ventilation design sometimes receives insufficient attention.

Designing ventilation systems to achieve good indoor environmental quality in small office buildings follows certain basics:

- Supply sufficient outdoor air
- Separate tenants and space use with ventilation zones

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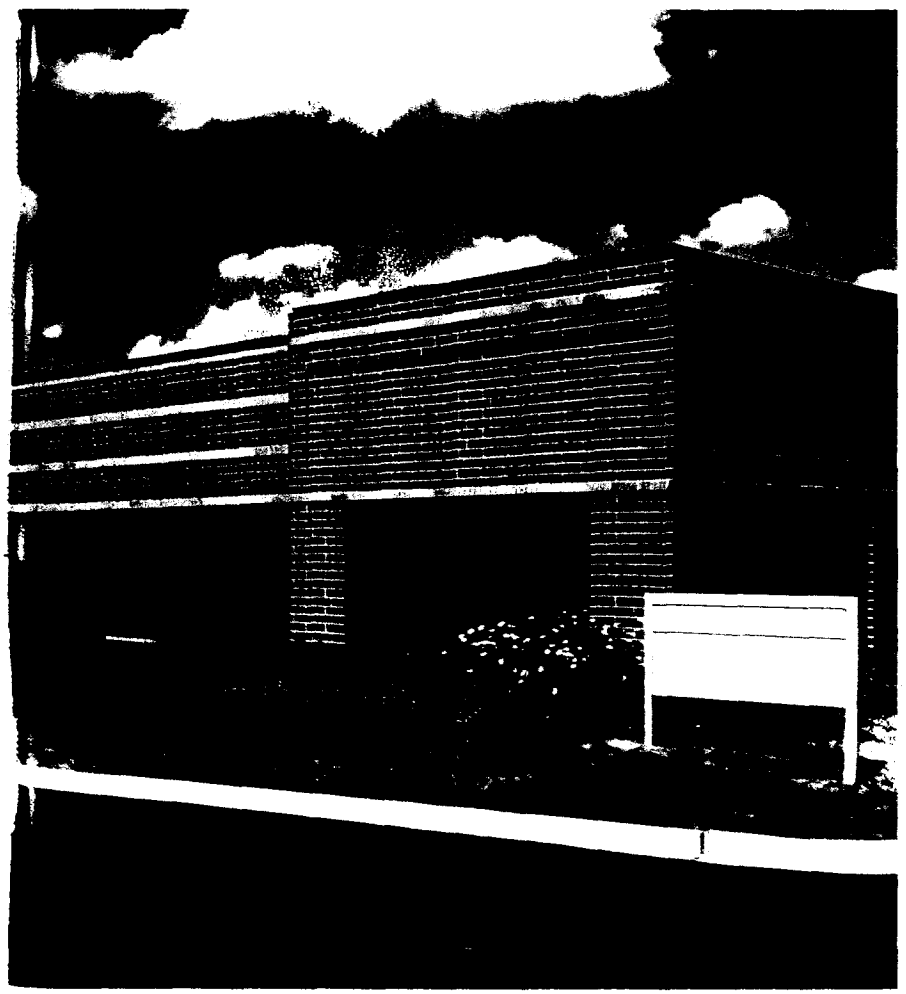
- Provide localized exhaust to remove airborne substances at or near their sources.

Within this context, space use planning can readily incorporate accommodation of smokers, an enhancement to indoor environmental quality likely to be important to many tenants of this type of building. For tenants electing to allow smoking throughout their facility, designing ventilation to supply sufficient outdoor air to meet the guidelines of ASHRAE 62-1989 should suffice. For tenants wishing to provide separate smoking and nonsmoking areas, use of pressure balance techniques and localized exhaust for smoking areas will enhance the environment. For larger tenants seeking a smoking lounge option, the slab floor and direct access to potential roof exhaust place no limitations on the design.

Typical design for single story office ventilation uses air handling units with passive return/exhaust, relying on exfiltration and kitchen and restroom exhaust to release outdoor air introduced through the fan system. The effect is to create a positive pressure on the building, which is as it should be, with small negative pressure zones around kitchen and restroom areas. Small kitchens and restrooms are typically incorporated into each tenant's space. The simplest and lowest cost approach to adding a smoking area or lounge is to increase the exhaust in the vicinity of these facilities to create an additional area of relative negative air pressure, isolating and exhausting tobacco smoke. These facilities are sometimes improperly exhausted into the ceiling plenum, rather than directly to the outdoors. Before implementing a smoking area or lounge that uses existing exhaust, check to be certain that the exhaust system vents to the outdoors.

Spring Lake Business Park, Itasca, Illinois—developed by Amli Realty Co.



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Technology Options

Impact of Standards

Indoor environmental quality is the sum of deliberate and accidental events in the design, construction, operation, and use of a building. A building represents a created environment, which is to say it comes into existence only by our deliberate action. As such, the indoor environment is in large part a function of the technology available for its construction and operation.

Technology issues abound in the design, construction, operation, and use of buildings. For example, as electronic control technologies continue to expand their reach into building design and operation, the role of the building engineer continues to change. Electronic monitoring has replaced many of the daily inspection rounds typical of building engineering and maintenance twenty or thirty years ago. For the indoor environment, that translates into more consistent control, but greater risk that some undetected event, like accumulation of water in a drain pan that gradually promotes growth of microorganisms, might produce contamination of the ventilation system. Higher and higher degrees of monitoring and control race to keep pace with opportunities to protect and enhance the indoor environment. In turn, codes and standards face the challenge of keeping pace with changes in building technology and use.

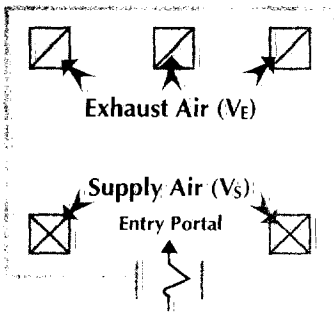
Beginning with a multi-dimensional useplan for a building, a designer is confronted with selection of the appropriate technologies for structural, mechanical, electrical, and related systems that can produce a high quality indoor environment within the project budget. The interactive process of useplanning, design, specification, budgeting, and redesign requires constant attention to the tenets of value engineering to meet the goal of affordable quality. A key part of this process is the evaluation of the technological options available, and the codes and standards that encourage or limit technology choices. Looking to the technology for accommodating smokers, which ranges from tried and true designs to innovative and creative solutions, a model emerges for evaluation of good management practice to achieve indoor environmental quality.

Codes and Standards

The operative national standard for ventilation, ASHRAE Standard 62-1989, provides a starting point for the evaluation of approaches for attaining adequate ventilation, while at the same time accommodating smokers and non-smokers in the indoor environment. Note that local codes and ordinances may have requirements more or less stringent than the ASHRAE Standard, and should be consulted for design guidance.

The accommodation of smoking and non-smoking has been a long-standing issue for the ASHRAE ventilation standard. In its original iteration ASHRAE Standard 62-73, *Standard for Natural and Mechanical Ventilation*, which is still referenced in many local codes, set minimum and recommended levels of ventilation. Under the influence of energy conservation goals and questions about minimum ventilation rates, review and revisions resulted in ASHRAE Standard 62-1981, *Ventilation for Acceptable Indoor Air Quality*, which set separate ventilation rates for smoking and non-smoking areas. Confusion resulting from the differentiation of smoking and non-smoking areas led to the revisions incorporated into the current version,

Simple Smoking Lounge Configuration



Exhaust Grille

Supply Diffuser

Smoking Lounge Example

Building Population (P) = 1,000 people
Average Lounge Occupancy (P_O) = 33 people
Net Occupiable Space (S_t) = 472 sq ft.
Total Transfer Air (V_T) = 1050 cfm
Total HVAC Ventilation Air (V_S) = 930 cfm
Total Exhaust Air (V_E) = 1980 cfm

Fig. 4

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Source: https://www.industrydocuments.ucsf.edu/docs/rklm0000

Calculating Ventilation Rates for Smoking Lounges Under ASHRAE Standard 62-1989

Smoking lounges are treated as a special case under ASHRAE Standard 62-1989. The Standard calls for higher ventilation rates for smoking lounges, but allows use of "transfer air," which is air drawn directly from other parts of occupied space. Here are the steps necessary to translate the ASHRAE Standard into a practical smoking lounge design.

1. Calculate the average occupancy (P_O). First, establish how many smokers populate (P_S) the area served by the lounge. This can best be done through a survey. If that is impractical, a rough estimate can be obtained by using the population average, 26%, applied to the building population (P). Second, establish the peak usage population to set the maximum occupancy (P_M) of the lounge from survey data, or for approximation, assume that 25% of the smokers will use the lounge at any one time around lunch hour. Third, calculate the average number of occupants in the lounge (P_O). Average occupancy must be greater than one half of maximum occupancy, in accordance with the ASHRAE Standard as it applies to areas of intermittent or variable occupancy. Here's an example that uses rough approximations:

   P = 1000 people
   $P_S = P * 26\% = 260$ smokers
   $P_M = P_S * 25\% = 65$ maximum number of smoking lounge occupants
   $P_O > (P_M / 2) > 65 / 2 > 32.5 = 33$ average number of smoking lounge occupants

2. Calculate the minimum floor area of the lounge (S_L). Use the average occupancy of the lounge (P_O) multiplied by the number of square feet per occupant (S_O) established in the ASHRAE estimated maximum occupancy to determine the minimum net occupiable space required for the smoking lounge. For example:

   S_O = 1000 sq ft / 70 maximum number of occupants = 14.29 sq ft per occupant
   $S_L = P_O * S_O = 33$ occupants * 14.29 sq ft = 472 sq ft net occupiable space

3. Calculate the minimum ventilation rate for the lounge (V_E). Multiply the average occupancy (P_O) of the smoking lounge by the outdoor air requirements (V_O) set for smoking lounges in ASHRAE 62-1989 to determine the minimum ventilation rate, here shown in cubic feet per minute (cfm) per person. The minimum ventilation rate equals the amount of air that must be removed from the lounge, and generally should be exhausted directly to outside. Hence the minimum ventilation rate for this calculation is assumed to be the same as the exhaust rate (V_E). For example:

   $V_E = P_O * V_O = 33$ occupants * 60 cfm = 1980 cubic feet per minute

4. Calculate the transfer air available for ventilation (V_T). For a simple smoking lounge, leaving the access to the room as an open portal rather than installing a door allows for both supply of transfer air and an effective air curtain to avoid the spread of smoke outside of the lounge. If the entrance wall is fire rated, a closable door will be necessary. In that case, use a transfer grille fitted with smoke or fire dampers as required. Using the open portal access, and assuming the transfer air is of sufficient quality, the calculation of transfer air is the product of two variables that are physical aspects of the design: the size of the entrance way (S_T), and the velocity of air (V_V) required for the air curtain effect. For reference, most people can sense air movement over 70 feet per minute, and laboratory hoods require a face velocity of 60 to 100 feet per minute. For example, using an air velocity lower than normally sensible:

   $V_T = S_E * V_V$ = (3 ft * 7 ft) * 50 feet per minute = 1050 cfm transfer air

5. Calculate the minimum supply air required for ventilation (V_S). The total supply air required will be determined by desired space temperature, internal heat gain, solar gain, transmission losses and related factors. Because of the high ventilation requirements for smoking lounges, and the high rate of transfer air assumed here, a simplified formula can suffice for this example. The ventilation air required to be delivered from the HVAC system to the smoking lounge is the remainder of the total exhaust air (V_E) less the transfer air (V_T) that enters through the entrance way to the lounge. For example:

   $V_S = V_E - V_T$ = 1980 cfm - 1050 cfm = 930 cfm supply ventilation air

Fig. 5

ANSI/ASHRAE Standard 62-1989, including Addendum 62a-1990.

The current version of the ASHRAE Standard simplifies the question of accommodation of smoking and non-smoking in the indoor environment through two basic mechanisms:

- Using the "Ventilation Rate Procedure" for design, ASHRAE Standard 62-1989 provides ventilation rates for generally occupied areas where moderate levels of smoking are expected, and specific ventilation rates for smoking lounges.
- Using the "Indoor Air Quality Procedure" for calculation, ASHRAE Standard 62-1989 provides for measurement of specific contaminants and subjective evaluation of the sufficiency of ventilation rates for adequate control of indoor air contaminants, including environmental tobacco smoke.

If a building owner or occupants elect to allow smoking throughout their facilities, the basic "Ventilation Rate Procedure" of Standard 62-1989 suggests outdoor air requirements that may be expected to produce acceptable indoor air quality. Similarly, should specific design challenges, such as restricted access to good quality outdoor air, set limits on available outdoor air, the "Indoor Air Quality Procedure" offers an alternate method for determining ventilation rates to satisfy occupants' perceptions of indoor air quality. Several other features of ASHRAE Standard 62-1989 afford selection of options for the advancement of technologies to accommodate smokers and non-smokers, such as the option to filter recirculated air as a substitute for outdoor air, and the consideration of plug flow (or displacement) ventilation techniques for increased ventilation effectiveness.

The effect of ASHRAE Standard 62-1989 requirements for ventilation is to set a floor for ventilation levels, and to encourage innovation in design to meet the specific needs of building occupants while permitting the accommodation of both smokers and non-smokers. The next few pages explore the basics and the innovations that can be used in this context.

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Source: https://www.industrydocuments.ucsf.edu/docs/rkim0000

Technology Options

Displacement Ventilation

One specific option within ASHRAE Standard 62-1989 for controlling specific types of contamination in indoor environments is called plug flow ventilation, now often referred to as displacement ventilation. The concept is elegant in its simplicity: air is introduced at or near floor level and uses the thermal gradient across the vertical plane of the room to create an upward airflow, which is then exhausted through ceiling grilles, removing any contaminants that may have been introduced in the room. Since the early 1980s, this technology has been demonstrated extensively in Northern Europe, where the cool, low humidity climate makes the plug flow concept an excellent choice for energy efficiency. For smoking lounges, displacement ventilation offers the potential for rapid removal of environmental tobacco smoke with minimal mixing in the space.

Important development efforts and demonstrations of displacement ventilation technology show how flexible and widely applicable the plug flow approach can be. Designs based on diffusers at floor level and systems using elevated flooring are being tested around the world. All of these designs offer the potential for improved energy efficiency, while raised floor designs add the possibility of integration of air supply and utility corridors for electrical and communications systems, and improved indoor air quality.

Displacement Ventilation Design Basics

Displacement ventilation systems begin with the introduction of air that is slightly cooler than mean room temperature at or near floor level. Demonstrations of the technology show that a temperature of 66° F to 68° F produces the desired thermal effect, while avoiding drafts and cold ankles for occupants. The air must be introduced at low velocity to minimize mixing near the floor area of the space. This is done by creating a large supply plenum with low pressure, rather than the traditional high pressure diffusers that stimulate turbulence. The flow in a displacement system derives from the buoyancy forces, which spread the supply air in a thin layer at the floor of the room. Heat sources within the space, such as occupants or office equipment, then generate plumes, drawing the supply air up and past them, lofting it toward the ceiling, where it is exhausted.

The radiant surfaces of the ceiling, floor, and walls all create complications for the design of displacement ventilation systems. The combined effects of the radiant behavior of the floor and ceiling and the thermal gradient across the vertical plane cause the floor to be slightly warmer than the air introduced by the system, while the ceiling is slightly cooler than the air being exhausted. Walls also represent radiant heat sources, and vary in thermal character with the seasons. These may create turbulence which effectively draws needed ventilation air away from occupied areas. Perimeter heating and cooling devices can be useful in overcoming this characteristic, particularly for exterior walls. Proper design parameters for the thermal gradients are

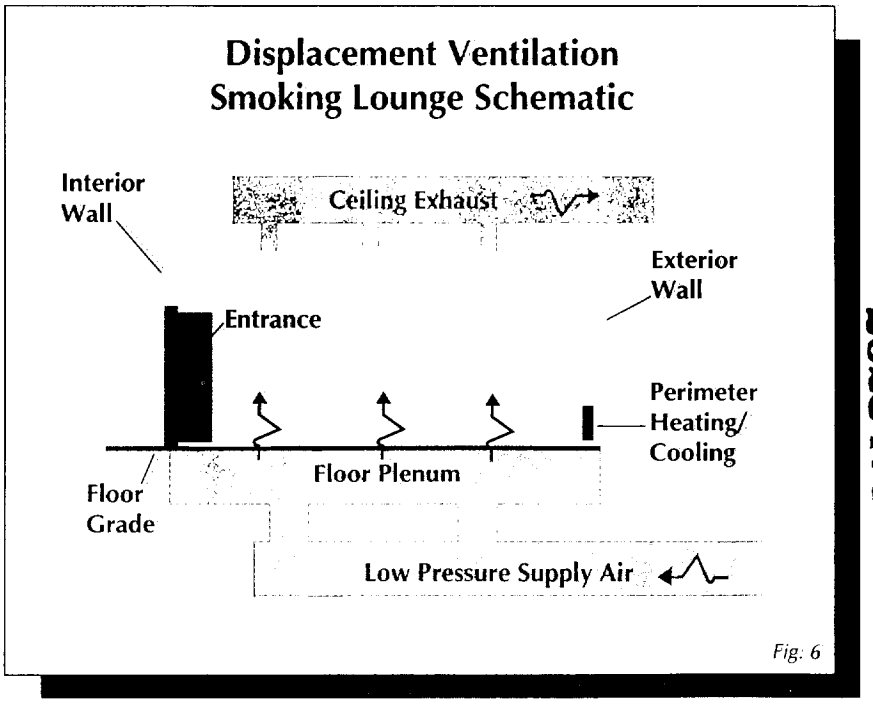

Fig. 6

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Source: https://www.industrydocuments.ucsf.edu/docs/rklm0000

critical to avoid thermal and contaminant stratification that might affect comfort and air quality in the breathing zone.

Smoking Lounge Applications

The logic of using displacement ventilation for smoking lounges comes from the effectiveness of the thermal plume generated by the smoker, creating an upward flow of air that sweeps environmental tobacco smoke up and away from room occupants into the ceiling area, where it is exhausted. The low velocities of the displacement ventilation approach provide a comfortable, draft-free environment without sacrificing contaminant removal efficiencies.

Floor level diffuser technology has proven effective in office and factory applications in Northern Europe. Elevated floor techniques have been demonstrated in practice for more than two years at one of the premier arts centers in the U.S., the Benedum Center in Pittsburgh, accommodating smokers in a non-smoking building. Designed to accommodate 100 smokers, the lounge supplies a minimum of 6,000 cfm of outdoor and treated, recirculated air through the floor of the room. The floor plenum, a computer floor covered with permeable carpeting, serves as a low velocity diffuser for the entire area. Six ceiling mounted exhaust/return grilles remove the warm air and tobacco smoke.

Displacement ventilation technology presents a great opportunity in the context of new building designs and major retrofit programs. All of the components of the displacement design are, in themselves, conventional. The principal challenge is designing the space to incorporate a low velocity terminal device in or near the floor. Experienced vendors from Europe now offer their systems in the U.S. With the concept proven in projects in both North America and Europe, the remainder of the challenge is establishing operating parameters that integrate ordinary HVAC equipment into an effective plug flow design.

▲ *The Benedum Performing Arts Center in Pittsburgh uses displacement ventilation technology to accommodate smokers in this convenient and comfortable lounge.*

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a self-contained smoking lounge ventilation system incorporating energy recovery could prove cost effective, while simplifying design parameters.

Air Filtration Technology

A variety of particle and gas phase filtration systems have entered the market to respond to special needs of some industries, and the growing general interest in indoor environmental quality. The specialized needs of laboratories, computer clean rooms, and manufacturing processes have spawned high efficiency particulate removal devices, ranging from fiberglass HEPA filters to electrostatic precipitators, as well as electrically and chemically active devices using negative particle charges, neutralization charges, ozone generators and a variety of activated carbon-based filters. The creativity of filtration device manufacturers has rapidly outstripped the standard-setting process at ASHRAE, leaving a gap in the methodology for evaluation of the effectiveness of filtration devices based on manufacturers statistics. Evaluating filters for treatment of return air from smoking lounges provides a sample of the opportunities this technological change may bring.

Current practice in ventilation system management provides experience with two basic options in advanced filtration: electrical field manipulation of contaminants, and use of chemical adsorbents in the context of fabric filters. Several variations on electrical cleaning are available commercially. Standard electrostatic precipitators have not generally proven effective in removing odors that are associated with tobacco smoke. Variations on precipitators that use electrical charges to agglomerate vapors and small particles for removal in conventional filters have anecdotal support in smoking applications. Similarly, activated carbon beds used with prefilters and medium to high efficiency filters downstream have proven effective for odor removal in smoking lounges, such as the one at the Benedum Center in Pittsburgh.

Occupancy Based Control for Smoking Lounge VAV Application

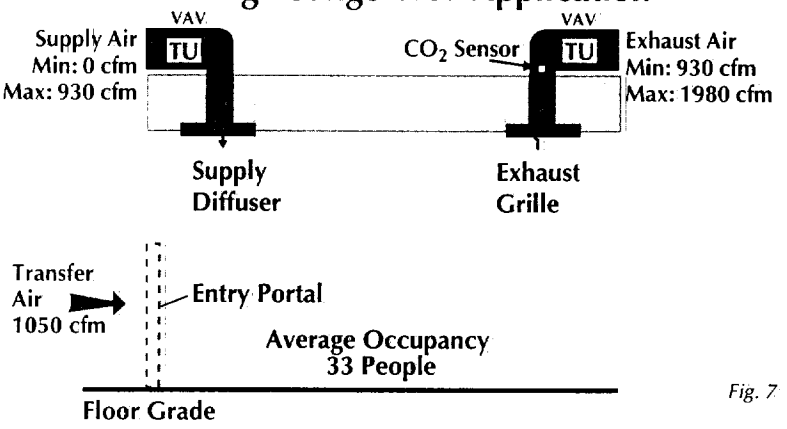

Fig. 7

Advanced Carbon Bed Filtration System

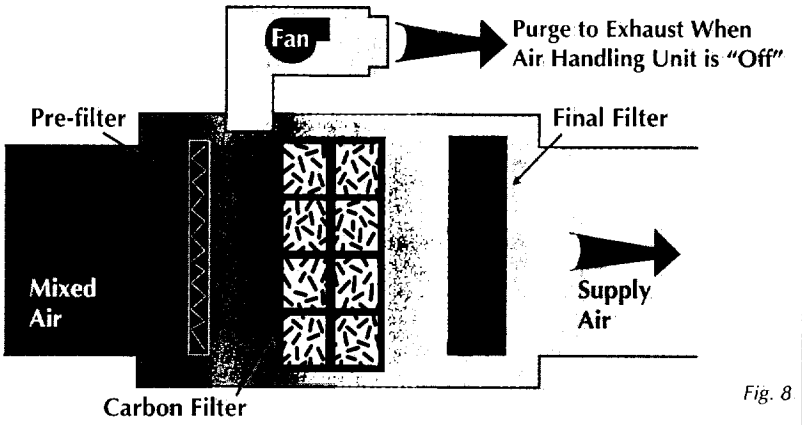

Fig. 8

"Run-around Loop" Heat Recovery

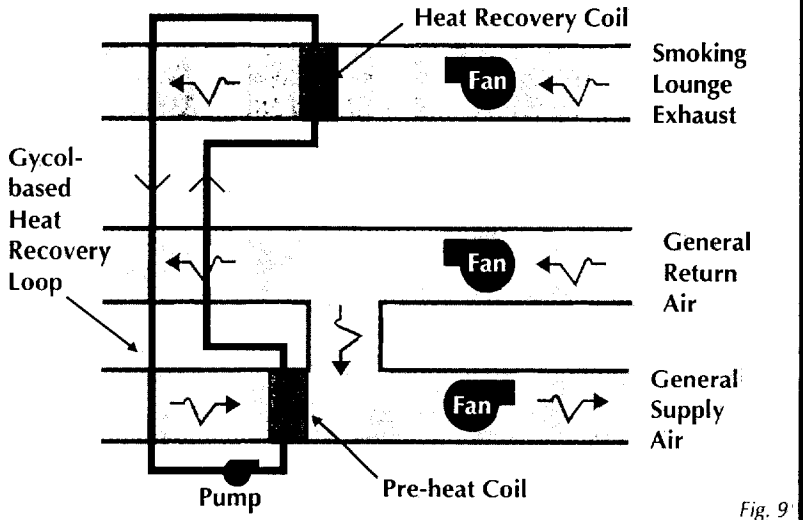

Fig. 9

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Technology Options

Energy Savings Systems

Indoor environmental quality and energy efficient operations can be compatible goals when pursued simultaneously in the design of new or extensively retrofit space. The ventilation rates recommended in ASHRAE Standard 62-1989 represent a significant increase in recommended levels of outdoor air from previous iterations—offices, for example, jumped from five cfm (cubic feet per minute) of outdoor air to twenty cfm per occupant. Several existing and emerging technologies offer ways to counter the increased energy use that this change in ventilation rates implies.

Designing a smoking lounge presents an even more interesting opportunity to integrate environmental quality and energy efficiency goals. ASHRAE recommends ventilation rates of 60 cfm per occupant for smoking lounges. The first energy efficiency opportunity derives from the ability to use transfer air to ventilate the smoking lounge. The transfer air, used in the smoking lounge and exhausted to the outdoors, represents a portion of the exhaust air needed to relieve the ventilation air introduced to adjacent spaces. Several other basic technical options are available:

- Automated control to reduce ventilation levels at lower occupancies
- Heat exchange devices for recovering latent energy in the exhaust
- Advanced filtration devices for full or partial recirculation of air removed from the lounge

Automated Control Options

Electronic direct digital control (DDC) of building mechanical systems has grown in sophistication as it has improved in ease of use. As indoor air quality and related issues push to the forefront of building management, developers and manufacturers of control systems have responded with an array of new sensors and related software to automate the management of this aspect of building control. Two key types of sensors are presently available for integration into most DDC systems: carbon dioxide (CO_2) sensors that indicate human occupancy, and gas sensors that determine the presence and concentration of volatile organic compounds (VOCs). Sensors are typically mounted in return ducts, sending an electronic signal to be translated into a monitoring or control point for the automation system. In control applications, the sensors can be used for modulation of outdoor air control dampers, variable air volume (VAV) systems, or both.

In the context of smoking lounges, a CO_2 sensor offers an excellent first step in energy efficiency by allowing control of supply and exhaust. In the context of a VAV design, a CO_2 sensor could be used to determine smoking lounge ventilation requirements. In an unoccupied lounge, the exhaust would be set to maintain the transfer air entering the lounge, while supply air from the HVAC system could be reduced to zero. As occupants enter the space CO_2 levels increase, signaling the VAV system to increase both exhaust and tempered supply air. The minimum settings for transfer air preserve the quality of the environment in and around the lounge, while energy to satisfy occupant needs is expended in the lounge only as the occupants require it.

Energy Recovery Technology

Several technologies have proven effective for recovering energy from an HVAC system exhaust: air-to-air heat exchangers; liquid medium heat exchange run-around loops; and more recently desiccant heat wheels. Air to air heat exchangers provide moderate efficiencies, typically around 55% to 70%, for pre-heating or pre-cooling outdoor air as it is introduced into an air handler. Heat exchange run-around loops, typically filled with a glycol-based solution, fulfill the same function and provide roughly the same efficiency. Desiccant-based heat wheels offer the potential of recovering both the sensible (temperature) and latent (humidity) components of the exhaust stream energy for reuse, resulting in a higher efficiency compared to other technologies.

Energy recovery technology offers an option in the accommodation of smokers and non-smokers by reducing the efficiency penalty from increased ventilation rates. From the perspective of accommodating moderate smoking in all areas, the preconditioning of outdoor air afforded by energy recovery systems can compensate for much of the increased outdoor air ventilation specified in ASHRAE Standard 62-1989. Some studies suggest that the most efficient of these technologies can provide overall system performance at 20 cfm outdoor air per occupant equivalent to a conventional design at 5 cfm per occupant. The technology can also be applied to energy recovery from exhaust systems serving smoking lounges. With the higher ventilation rates for smoking lounges suggested in the ASHRAE Standard,

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Technology Options

Air Pressure Zones

The open floorplan of the modern office provides greater flexibility in layout and use over time, but presents challenges in achieving indoor environmental quality from several perspectives. One of the most challenging aspects of the open floor plan approach is the variety of uses such space might be called upon to support. Often single cubicles and small groupings of occupants are adjacent to equipment centers where printing and copying take place, or near conference areas, where white board markers are frequently used. These layouts accommodate work flow, but may produce varying ventilation requirements to overcome the heat and emissions generated by these diverse activities. Using balancing of the supply and return/exhaust systems for an open floorplan area provides a basis for zoning sections of the area for specific uses without building walls.

The scope of this opportunity for improving the indoor environment can be seen in the design of an open area to accommodate both smokers and non-smokers. Air generally flows from areas of higher air pressure to areas of lower air pressure, from positive pressure in the direction of negative pressure. Using this simple concept, areas set aside for non-smokers can be maintained at a slight relative positive air pressure, while areas set aside for smokers can be maintained at a slight negative relative air pressure. This will produce a slight air flow from the non-smoking area into the smoking area, keeping the air from the smoking area from mixing with that in the non-smoking area. Through thoughtful planning and carefully supervised and tested balancing of the HVAC system, the preferences of both smokers and non-smokers can be accommodated without any additional cost to building operations.

Air Pressure Zoning Basics

Use of air pressure to create specific zones within an open area requires a rethinking of normal ventilation design. Conventional ventilation systems are designed to maximize the mixing between the air that is introduced into the space and the air that is already there. This mixing is called ventilation effectiveness. In a large open area, the air introduced from the overhead air diffusers mixes thoroughly throughout the area. Slightly more air is supplied to the area than is exhausted to keep the area at a slightly positive air pressure relative to the building envelope and access points. In this context, the large open area described here represents a single, positive pressure zone.

Beginning from a carefully developed useplan, this large single zone can be subdivided into smaller areas where specific activities, such as smoking, may take place without affecting occupants in other areas. Once the boundaries between zones are defined in the useplan, the ventilation layout can be adjusted to accommodate smoking areas. Overall ventilation rates for all areas should be sufficient to meet ASHRAE 62-1989 guidelines. Within that context, ventilation should be sufficient to accommodate a moderate amount of smoking. Total air supply for the general use area (S_G) should be slightly greater than the return/exhaust from the general use area to create a slight positive pressure relative to smoking areas (S_S). The quantity of air removed from the smoking area (R_S) should be approximately ten percent greater than the amount of air supplied to it to create a slight negative pressure. The quantity of air removed from the general use areas (R_G) should be less than the amount supplied to those areas by an amount sufficient to compensate for the added removal rate from the smoking area, while leaving an overall positive pressure in the space.

For example:

$$R_S = 1.1 * S_S$$
$$R_G = (0.95 * S_G) + (S_S - R_S)$$
$$(S_G + S_S) > (R_G + R_S)$$

The result of the pressure differential between the smoking area and the general use area is to create an air pressure barrier between the two areas that prevents the air in the smoking area from mixing with the air in the general use area. The exact proportions of the pressure relationships between general and special use areas can be adjusted to accommodate the varying degrees of activity that come with different uses, with higher degrees of activity generally requiring higher pressure differentials. This approach brings the added benefit that smokers and non-smokers can be accommodated without measurably influencing the initial capital cost or operating efficiency of the building.

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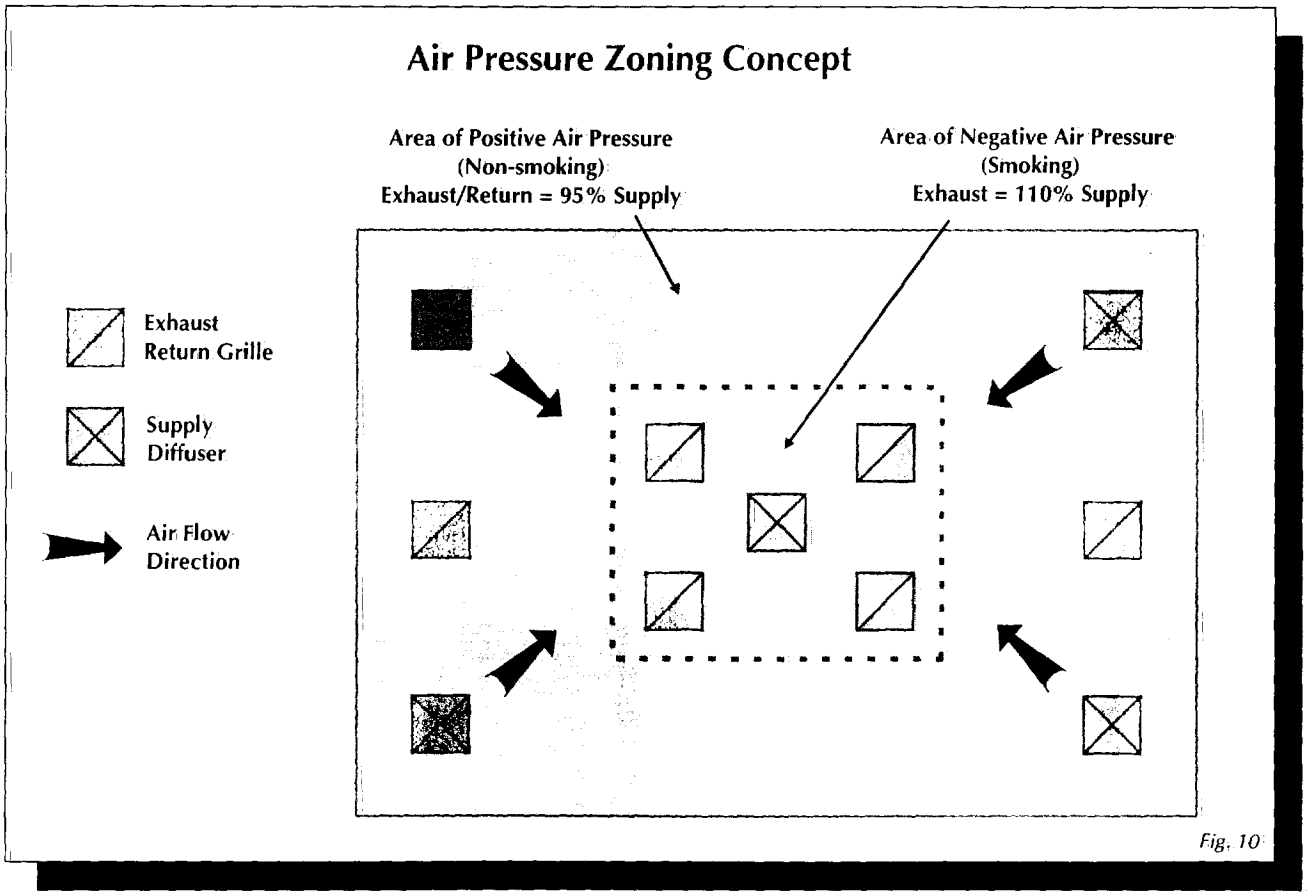

▲ *The use of air pressure zones to create smoking areas is an especially useful technology option for reception areas, cafeterias, and restaurants.*

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Technology Options

Individual Smoking Areas

Several advances in technology make it possible to go beyond the designation of smoking lounges or smoking areas, and to allow individuals to choose whether they wish to have their own personal work environment as a smoking or non-smoking area. Allowing individuals this degree of choice presents an opportunity to reduce personal and organizational stress, while enhancing personal productivity.

Technical Options for Individual Smoking Areas

Several technologies allow individuals the choice of making their individual workspaces smoking or non-smoking. Whether the workspace is defined by a cubicle or an office wall, the key to this form of accommodation is to avoid mixing air from smoking and non-smoking areas. Three basic technical alternatives predominate:

- Filter the air in each workspace separately
- Pressurize each workspace using a local air supply
- Create a displacement (or plug flow) ventilation environment

Workspace filtration creates a local ventilation "bubble" in which an individual receives general ventilation air from central HVAC systems, then has a self-powered filtration unit which cleans and recirculates the air in their office or cubicle. For accommodation of smokers and non-smokers, filters must be capable of removing particulates and adsorbing vapors and gases. A combination pre-filter, activated carbon cell, and high efficiency particulate filter will accomplish this. Odors may occur as the carbon filters desorb when the units are off, or when carbon cells are not changed frequently enough.

Localized air supply to each workspace offers the option of ventilation and temperature control by the occupant. In most designs, low velocity air is supplied through a floor plenum, which allows flexibility in the location of ducting to individual workstations. A personal air diffuser and a control panel in each cubicle allow the occupant to control air flow. In some designs, air for corridors and other common areas comes from the "spill over" from the individual workstations. For systems to accommodate both smokers and non-smokers, common areas will need to be ventilated sufficiently to assure that any mixing of air from cubicles and common areas occurs only above the breathing zone.

Where an entire area is ventilated with displacement ventilation, the upward flow of ventilation air creates personal zones wherever a person is located. The person's presence creates a plume of ventilation air that brings supply air up from floor level and propels it into the exhaust zone. Total design based on displacement ventilation affords maximum flexibility in location of furnishings, as well as effective removal of not only tobacco smoke, but all airborne materials from the breathing zone of occupants.

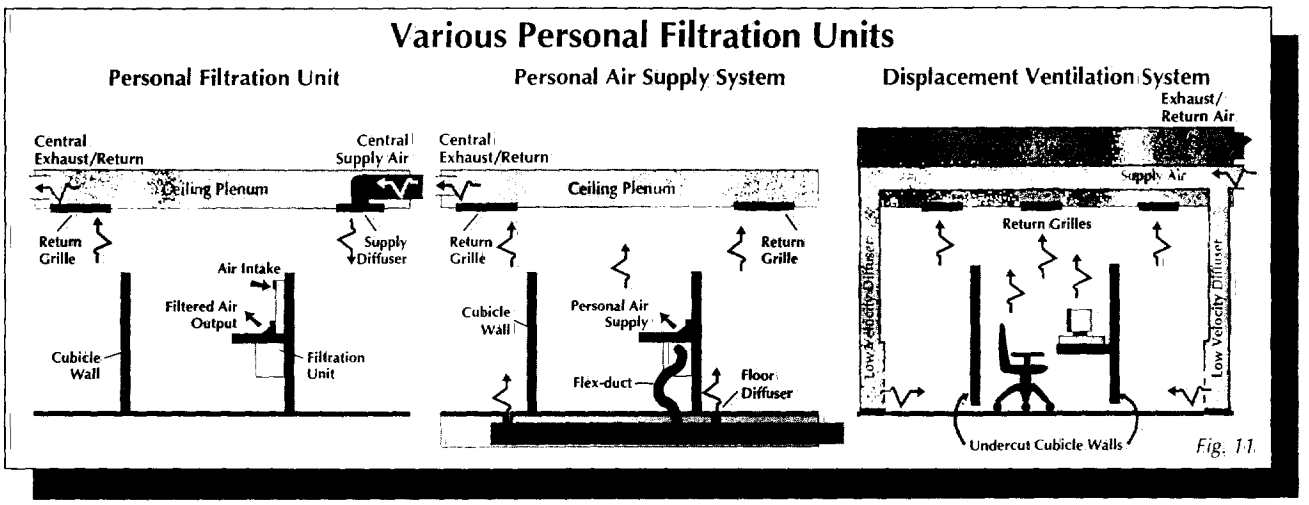

Fig. 11

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Functional Design

Improving the indoor environment requires a complete, multi-dimensional useplan to take full benefit of investments in good engineering and new technology. Underlying the specific objectives of each building owner or tenant, the broad goals of improving productivity and minimizing personal and organizational stress enliven designs for indoor environmental quality. Each space within a well designed indoor environment should contribute to these goals.

In the context of designing smoking areas, particularly if a separate area or lounge is provided, the useplan should incorporate not only sufficient ventilation for its use, but practical features, such as desks and telephones, allowing smokers to remain productive throughout the day and minimizing personal and organizational stress. An individual using the lounge need not interrupt important work to smoke, which avoids the organizational perception that use of the smoking area is a "break."

Design Features for Functionality

Some of the options that should be considered in the useplanning process range from simple furniture selection to high-tech communications system integration. No detail should be overlooked. Furnishings should be oriented to the primary use of the area. For example, if the area is a smoking lounge, specifically designed for relatively brief use, a few tables and chairs for small group discussions can be combined with stand-up desks equipped with telephones, where a busy executive can set a notepad or portable computer and make a few phone calls. If the lounge is used by more than one tenant, support systems such as telephones can be provided on a credit card only or other custom billing basis.

Going beyond minimal accommodation, smoking areas can be designed with features such as special project areas, where smokers working on intensive projects can find temporary sanctuary and excellent working conditions. Providing a computer workstation or a port to data communications in the smoking area can dramatically enhance productivity. Small conference areas within the smoking area can also provide smokers and non-smokers with meeting and speciall project areas that help minimize organizational stresses. Once the basics of proper ventilation are achieved, creative useplanning opens a wide horizon for improving indoor environmental quality.

◀ *A well designed smoking area provides features for functionality, such as a convenient place for smokers and non-smokers to meet.*

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Source: https://www.industrydocuments.ucsf.edu/docs/rklm0000

The Accommodation Model

The changes in the way people think about the buildings they occupy require designers to ask not what uses will be allowed, but how the many and varied uses can be accommodated. For each new building or major retrofit, the heart of this question for the designer rests in a carefully conceived and thoroughly tested multi-dimensional useplan.

The useplan grows from the project objectives set out by the building owner. Progressive layers of detail emerge as the overall shape of the building begins to conform with its purposes. From the shape of the exterior emerge the dimensions of the interior environment, not only in feet and inches but in light and air and sense of space. The dimensions of the interior space form the first lines of the patterns of use that will ultimately enliven and fill the building. Inch by inch, row by row, the many and varying uses of each measure of interior space define what structural and mechanical systems will be required, what life safety features, then what special features and support systems, what electrical and communications systems, what floor and wall coverings, furniture and lights. The useplan and the design intertwine as the idea of the building unfolds into drawings and models.

Interactive Planning

As the successive layers of design detail overlay the basic plans of the building, the useplan becomes the benchmark and the evaluation tool. The designer must set the design and the useplan side-by-side and approach them with a series of questions:

- Are both the useplan and the design consistent with the owner's objectives?
- For each planned use, have all applicable codes and standards been satisfied?
- Have the best choices of materials and equipment been made on the basis of value engineering?
- Does the design contribute to acceptable indoor environmental quality?
- Can the building be maintained over its lifetime to sustain both value engineering and environmental quality goals?

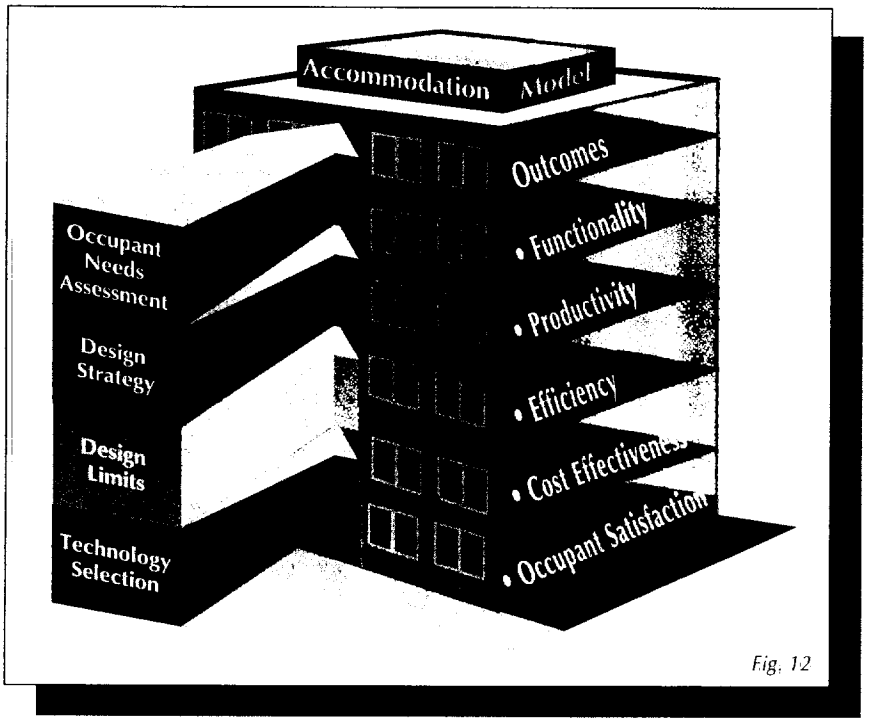

Fig. 12

◀ *A multi-dimensional useplan provides a basis for the accommodation model for achieving indoor environmental quality.*

Evaluating Indoor Environmental Quality

Good design for indoor environmental quality produces a building that enhances productivity and minimizes the physical and psychological stressors on building occupants. A commitment to environmental design requires the same multi-disciplinary team approach typically applied to traditional engineering disciplines. To the mechanical, electrical, and structural evaluations must be added functionality, ergonomics, air quality, usability, maintainability, and aesthetics. To the analysis of cost effectiveness of equipment and material selections must be added consideration of product emissions and

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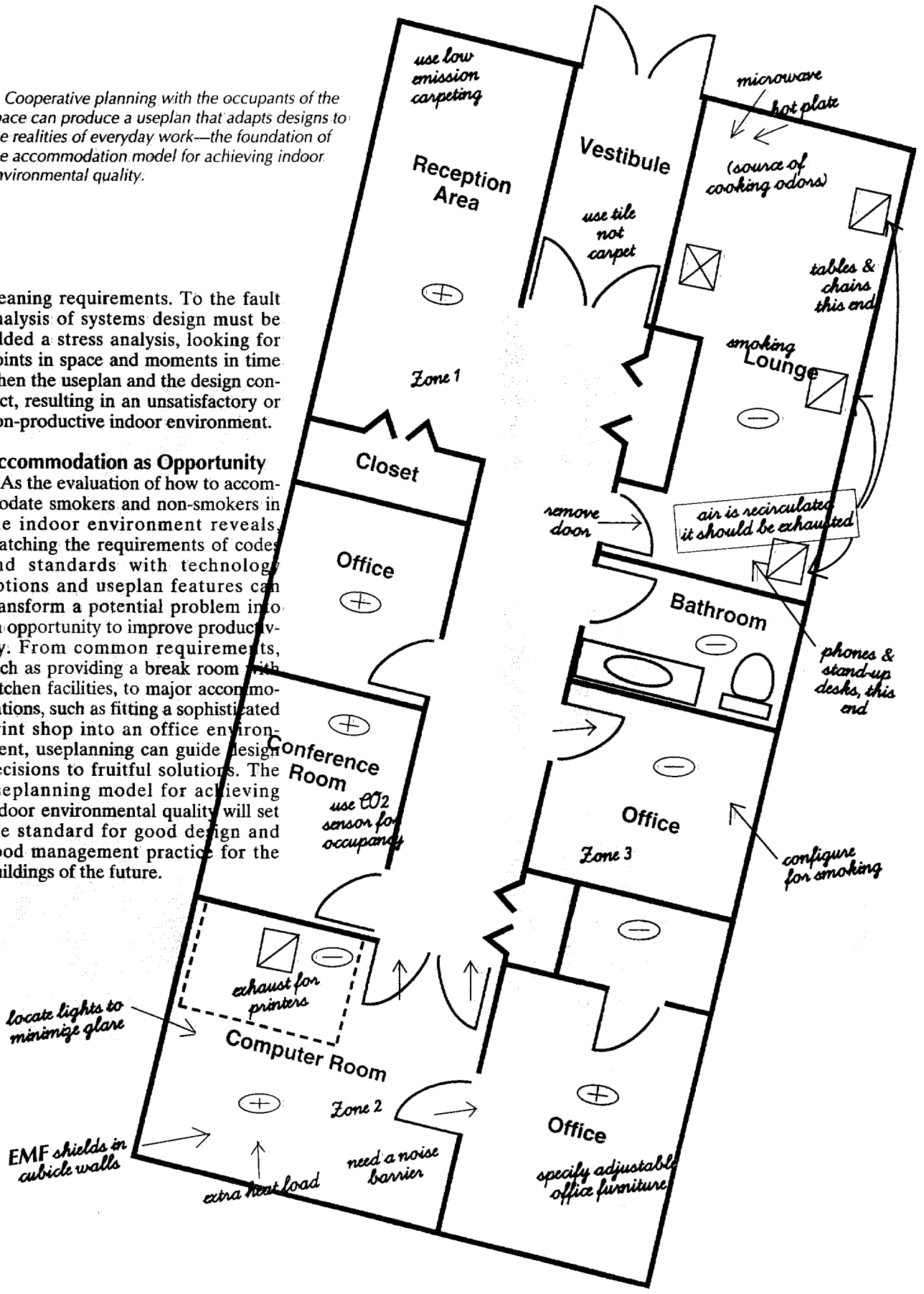
Source: https://www.industrydocuments.ucsf.edu/docs/rklm0000

▶ *Cooperative planning with the occupants of the space can produce a useplan that adapts designs to the realities of everyday work—the foundation of the accommodation model for achieving indoor environmental quality.*



cleaning requirements. To the fault analysis of systems design must be added a stress analysis, looking for points in space and moments in time when the useplan and the design conflict, resulting in an unsatisfactory or non-productive indoor environment.

Accommodation as Opportunity

As the evaluation of how to accommodate smokers and non-smokers in the indoor environment reveals, matching the requirements of codes and standards with technology options and useplan features can transform a potential problem into an opportunity to improve productivity. From common requirements, such as providing a break room with kitchen facilities, to major accommodations, such as fitting a sophisticated print shop into an office environment, useplanning can guide design decisions to fruitful solutions. The useplanning model for achieving indoor environmental quality will set the standard for good design and good management practice for the buildings of the future.

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